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Vocational and Technical Education in Indonesia: Theoretical Analysis and Evidence on Rates of Return

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Vocational and Technical Education in Indonesia: Theoretical Analysis and Evidence on Rates of Return

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Abstract

The central theme of this paper is the optimum mix of vocational and technical education (VOTEC) and general education in the curriculum. The optimum degree of vocationalization occurs where the net returns from the educational investments are highest. In this paper, the rates of return to VOTEC and general education are derived in a nested CES structure which incorporates different rates of nonneutral technical progress.

This paper then calculates and interprets the rates of return to secondary VOTEC and general education using the newest 1986 Indonesian data. The overall rates of return are somewhat higher for general education, but differ substantially by province and also by sex.

Contents

I. INTRODUCTION 1

II. THEORETICAL ANALYSIS OF RATES OF RETURN FROM THE NESTED CES FUNCTION 2

III. THE THEORY OF RATES OF RETURN WITH TECHNICAL PROGRESS 8

IV. EVIDENCE ON RATES OF RETURN 12

V. SUMMARY AND CONCLUSIONS 14

I. INTRODUCTION

This paper develops a new analytical framework for calculation of the rates of return to vocational and technical education (VOTEC). Using a nested constant elasticity of substitution (CES) structure, we analytically illustrate the complementarity between VOTEC and general education, and the higher elasticity of substitution between these and raw unimproved labor. These relations are incorporated into the calculation of the rates of return to each type of education.

Our analysis is also new in that it takes into account the effect of technical progress on the rates of return. We show that how technical progress enters the production function, and how it affects the rates of return to the different types of education when it is nonneutral. The optimum degree of vocationalization of the curriculum and its implications for the performance of the economy are explored in this context.

To recapitulate, the major theoretical contribution of the paper is taking into account embodied technology and tracing its effects in a nested CES structure where elasticities of substitution differ.

This paper then considers the updated rates of return to VOTEC and general education at the secondary school level in Indonesia. Using the most recently available 1986 data, the social rates of return to each type of education are calculated by means of calculating a pure internal rate of return. The rates of return are disaggregated by sex and also by province so that there is a control for geographical aggregation bias stemming from the use of nation-wide data. This geographical breakdown has direct implications for the country's educational policy.

The organization of the paper is as follows. The first two sections develop the theoretical framework for the rate of return analysis, in which the rates of return are derived in the form of marginal productivities from the nested CES production function. The first section does so with a simple production function assuming no technical progress, and the second section adds

technical progress to the analysis. The third section considers the updated calculations of the rates of return to VOTEC in comparison with those to general education for Indonesia in the light of the preceding theoretical analysis. In the last section, we summarize the results and draw some conclusions with policy implications.

II. THEORETICAL ANALYSIS OF RATES OF RETURN FROM THE NESTED CES FUNCTION

A major issue is the optimum VOTEC-general education mix in the curriculum at any given education level. For economic efficiency, the curriculum mix should be determined so that the resulting economic returns from the mix of VOTEC and general education are highest. A rate of return analysis that takes the contribution of technology to productivity into account thus has been utilized as a way to evaluate the relative pay-off of VOTEC in comparison to general education. The effects of embodied technology on the social rate of return calculated by means of a pure internal rate of return which equates the present value of benefits to that of costs are considered later.

Complements or Substitutes ?

The approach in this paper differs from others in that it derives the rates of return explicitly from a production function. The main argument here is that VOTEC and general education are complements, rather than substitutes for each other. VOTEC embodies occupation-specific skills and the new technology that are readily applicable to the future job. On the other hand, general education is more broad and basic in nature, enhancing individuals' ability to learn on

the job and to receive and benefit from further on the job training.[1] Occupation-specific skills obtained from VOTEC and basic skills obtained from general education are complementary in that both types of skills are useful for success in the labor market. Occupation specific skills are immediately useful at work and thus are generally associated with higher initial earnings and lower initial unemployment. Therefore, a complete program of general courses usually means a sacrifice of initial earnings and somewhat longer average job search at the entry level. However, vocational skills have large effects on productivity only when there is a correspondence between one's vocational skills and one's job, as Bishop (1989b) points out. Accordingly, too much specialization in vocational courses involves a risk of not being profitable in the future job should job requirements change. On the other hand, basic skills are important in every type of job, although their immediate effects on productivity may be smaller than occupation-specific skills. Further, basic skills enhance the ability to learn vocational skills, and vocational courses showing the relevance of basic skills can feed back and improve learning in general education courses. So there is complementarity both in learning and later in use of the more general and the more applied concepts and skills.

This complementarity between VOTEC and general education and its implications for the determination of the efficient curriculum mix has been explored in a CES structure in McMahon (1988). The complementarity has also been empirically supported for the non-college-bound high school students in work by Kang and Bishop (1989). In their work, returns are found to be decreasing from complete specialization indicating that VOTEC and general education reinforce each other, and thereby implying that a proper balance between these two types of education is needed to be effective. This suggests that the educational curriculum should provide both VOTEC and general education to gain the largest benefits from educational investment.

Therefore, the theoretical problem is to choose the optimal VOTEC-general education investment mix, not choosing one over the other. As will be shown below, the efficient mix can be obtained by following the expansion path which yields the highest rates of return, if these rates of return are estimated properly.

The Theory of Complementarity in Production and Rates of Return

Graphically, the complementarity between VOTEC and general education can be illustrated by use of the isoquants. In Figure 1A, occupation-specific skills created by VOTEC are measured on the vertical axis, and basic skills created by general education are measured on the horizontal axis. The isoquants ($Z_1 < Z_2$) corresponding to the different levels of real output (or income) are drawn with a proviso that occupation-specific skills and basic skills are complements, and hence distant substitutes. The isoquants for occupation-specific skills and the other type of production factor, say, raw unskilled labor (i.e., labor without either type of education) may be drawn flat, reflecting the higher degree of substitutability between these two inputs. Thus, it is assumed that the elasticity of substitution is quite low between VOTEC and general education, whereas the elasticity of substitution is relatively high between educational capital (VOTEC and general education) and raw unskilled labor.

There is complementarity not only in the economy in the use of skills created by each type of education as inputs in production, but also among curricula in schools. Figure 1B shows the complementarity in the learning process between vocational courses and general subject courses in the curriculum. Any point on the vertical axis represents vocational-track curricula while any point on the horizontal axis represents academic-track curricula. The line OC indicates "comprehensive curricula" where both VOTEC and general courses are included. The isoquants

($X_1 < X_2$) then reflect the learning outcomes from the combination of VOTEC and general courses.

Figure 1 here.

The complementarity/substitutability relationships among production inputs have been explored in line with the "capital-skill complementarity hypothesis", the hypothesis that skilled (educated) labor is more complementary with physical capital than unskilled labor (Griliches, 1969). Earlier empirical studies along this line generally support the hypothesis, as shown in the review article by Hamermesh and Grant (1979). A nested CES production function, originally introduced by Sato (1967), has been used to test the hypothesis by Fallon and Layard (1975), and more recently by a series of the Dutch studies. Broer and Jansen (1988) reports that the elasticity of substitution is very high (1.3) between physical capital and less educated labor (primary school) while it is almost nil (0.01) between physical capital and highly educated labor (college education) and between less educated labor and highly educated labor. The substitution elasticities are estimated to be more moderate in work by Ritzen (1987, 1989). For both the United States and the Netherlands, the elasticity of substitution between less educated labor and physical capital is around 0.6, whereas the elasticity between highly educated labor and the other types of inputs is around 0.2.

In this paper, a nested CES production function is used to express the complementarity between VOTEC and general education in comparison with the higher substitutability between skills obtained from these types of education and other inputs. Applying the different elasticity of substitution to vocational skills and basic skills on the one side, and basic skills and raw

unskilled labor on the other, the function can be specified as the following:

$$Y = A[\alpha_1 Z^{-\rho} + \alpha_2 N^{-\rho}]^{-\frac{1}{\rho}}, \quad \alpha_1 + \alpha_2 = 1, \quad \rho \geq -1 \tag{1}$$

$$Z = B[\beta_1 V^{-\rho_z} + \beta_2 G^{-\rho_z} + \beta_3 K^{-\rho_z}]^{-\frac{1}{\rho_z}}, \quad \beta_1 + \beta_2 + \beta_3 = 1, \quad \rho_z \geq -1 \tag{2}$$

where Y stands for the total output (or earnings) and Z for the intermediate product. N denotes raw labor, V and G, respectively, denote the skills created by VOTEC and skills created by general education and K denotes physical capital.[2] For simplicity, higher education is omitted, the efficiency parameters A and B are set equal to one hereafter, and the degree of homogeneity is assumed to be one at both levels.

The elasticity of substitution at the first level of production, σ_z, is obtained as

$$\sigma_z = \frac{1}{1 + \rho_z}. \tag{3}$$

and the elasticity of substitution at the second level, σ, is

$$\sigma = \frac{1}{1 + \rho}. \tag{4}$$

At the outset, we assumed that the skills accumulated from VOTEC and skills from general education are complements for each other, while these skills taken together are rather close substitutes with raw unskilled labor. It follows that the elasticity of substitution between vocational skills and basic skills should exceed the elasticity of substitution between these skills and raw unskilled labor. That is, $\sigma > \sigma_z$.

Rates of Return Assuming No Technical Progress

We now turn to the derivation of the rates of return from this production function. Substituting equation (2) into equation (1), we have

$$Y = [\alpha_1 \{\beta_1 V^{-\rho_z} + \beta_2 G^{-\rho_z} + \beta_3 K^{-\rho_z}\}^{\frac{\rho}{\rho_z}} + \alpha_2 N^{-\rho}]^{-\frac{1}{\rho}}. \tag{5}$$

Taking the total derivative of (5) with respect to time t, we have

$$\begin{aligned}\frac{dY}{dt} &= \frac{\partial Y}{\partial V}\frac{\partial V}{\partial t} + \frac{\partial Y}{\partial G}\frac{\partial G}{\partial t} + \frac{\partial Y}{\partial K}\frac{\partial K}{\partial t} + \frac{\partial Y}{\partial N}\frac{\partial N}{\partial t} \\ &= \alpha_1\beta_1\left(\frac{Y}{Z}\right)^{\rho+1}\left(\frac{Z}{V}\right)^{\rho_z+1}\frac{\partial V}{\partial t} + \alpha_1\beta_2\left(\frac{Y}{Z}\right)^{\rho+1}\left(\frac{Z}{G}\right)^{\rho_z+1}\frac{\partial G}{\partial t} \\ &\quad + \alpha_1\beta_3\left(\frac{Y}{Z}\right)^{\rho+1}\left(\frac{Z}{K}\right)^{\rho_z+1} + \alpha_2\left(\frac{Y}{N}\right)^{\rho+1}\frac{\partial N}{\partial t}. \end{aligned} \tag{6}$$

Therefore, the rate of return to VOTEC is

$$r_V = \alpha_1\beta_1\left(\frac{Y}{Z}\right)^{\rho+1}\left(\frac{Z}{V}\right)^{\rho_z+1}, \tag{7}$$

and the rate of return to general education is

$$r_G = \alpha_1\beta_2\left(\frac{Y}{Z}\right)^{\rho+1}\left(\frac{Z}{G}\right)^{\rho_z+1}. \tag{8}$$

Note that the rates of return to each type of education are determined by the substitution elasticities as well as by the distribution parameters α's and β's.

The complementarity between VOTEC and general education implies that both types of education are required in the production process and they reinforce each other. In other words, the expansion of VOTEC could increase the demand for general education more rapidly than, say, the demand for unskilled labor. If general education is not properly expanded corresponding to the growth of VOTEC, the above-equilibrium rate of return to general education could persist. The result will be a slow-down of production (growth) due to failure to invest scarce resources where the rates of return are highest. Therefore, a balanced expansion of VOTEC and general education would be necessary to maintain the efficiency in production.

By estimating parameters in equation (5) and substituting in the values for each variable, we can solve for the rates of return to each type of education. These rates of return estimated from the parameters of the production function can then be used to evaluate the pay-off of each type

of education. The higher rate of return implies the greater cost-effectiveness, other things being equal, and thus implying the higher profitability of further investment.

Also, this theoretical solution for the rates of return can be used to determine the optimum VOTEC and general education mix, as shown in Figure 2. The optimum mix will be obtained where the rates of return are highest. The optimum VOTEC-general education curriculum mix is represented by point $B(G_1, V_1)$ in Figure 2, where the rates of return to both are at a maximum given the budget constraint (I_1I_1). At point A, general education is overexpanded, resulting in lower returns (represented by the lower level of isoquants). Conversely, at point C, VOTEC is overexpanded, with a low rate of return to VOTEC and a relatively high rate of return to general education. Movement from C to B raises the output from Z_0 to Z_1 while reducing the stock of vocational skills from OV_2 to OV_1. From equation (1), the increase in Z causes Y to grow, other things being equal. It follows from equation (7) that the rate of return to VOTEC rises. The efficient expansion path is thus given by the line *OBE* on which the most efficient balance between the two types of education is maintained.

Figure 2 here.

III. THE THEORY OF RATES OF RETURN WITH TECHNICAL PROGRESS

In the previous section, we have derived the rates of return under the assumption of no technical progress. In practice, however, technical progress is a major impetus for economic growth, apart

from increases in capital and economies of scale. The technology existing at a given point in time sets limits on how much can be produced with a given amount of inputs, delineating the way in which resources can be combined to yield outputs. In this section, we extend our rate of return analysis to include the technical progress term.

Neutral and Non-neutral Technical Progress

Technical progress is called neutral if it leaves the marginal rate of technical substitution (MRTS) unchanged at the given factor intensity ratio. In most cases, technical progress is likely to differ in its effect on each type of input, and thus be nonneutral. Allowing the differing effect of technical progress, our earlier specification of the nested CES function can now be expressed as

$$Y = A[\alpha_1 Z^{-\rho} + \alpha_2 (e^{a_N} N)^{-\rho}]^{-\frac{1}{\rho}}, \quad \alpha_1 + \alpha_2 = 1, \quad \rho \geq -1 \tag{9}$$

$$Z = B[\beta_1 (e^{a_V} V)^{-\rho} + \beta_2 (e^{a_G} G)^{-\rho_z} + \beta_3 (e^{a_K} K)^{-\rho_z}]^{-\frac{1}{\rho_z}}, \quad \beta_1 + \beta_2 + \beta_3 = 1, \quad \rho_z \geq -1. \tag{10}$$

In the above equations, a_N, a_V, a_G, and a_K represent, respectively, raw labor-augmenting, vocational skills-augmenting, basic skills-augmenting, and physical capital augmenting technical progress. As before, we assume for simplicity the unitary efficiency parameters (i.e., A=B=1), no higher education, and linear homogeneity at both levels. In addition, since new technology tends to be adopted by educated labor rather than by raw unskilled labor, we further assume that technical progress applies mostly to either vocational skills or basic skills (i.e., $a_N = 0$). The comparative advantage of educated labor in implementing new technology has been addressed in Bartel and Lichtenberg (1987).

The effect on the optimum VOTEC-general education mix of the different types of technical progress is illustrated in Figure 3. If technical progress applies equally to vocational and technical

skills and skills created by general education (i.e., $a_V = a_G$), the isoquants are shifted in such a way that the MRTS is not altered for any given factor intensity ratio and the expansion path is along the vector Ok_i (i = 1, 2, 3). Accordingly, technical progress does not change the optimum vocationalization in the curriculum.

On the other hand, if technical progress is more of the basic skills-augmenting type, the derived demand for general education will increase relative to the derived demand for VOTEC. The resulting optimum curriculum mix puts more emphasis on general education, shifting the factor intensity and optimum expansion path from Ok_1 to Ok_2. Technical progress which chiefly augments vocational skills raises the derived demand for VOTEC compared to general education, and thus shifts the factor intensity and expansion path from Ok_1 to Ok_3.

Figure 3 here.

Effects of Technical Progress on Rates of Return

We now explore how the different types of technical progress affect the rates of return to VOTEC and general education. From equations (9) and (10), we have

$$Y = [\alpha_1\{\beta_1(e^{a_V}V)^{-\rho_z} + \beta_2(e^{a_G}G)^{-\rho_z} + \beta_3(e^{a_k}K)^{-\rho_z}\}^{\frac{\rho}{\rho_z}} + \alpha_2 N^{-\rho}]^{-\frac{1}{\rho}}. \tag{11}$$

Taking the total derivative of (11) with respect to time t, we have

$$\begin{aligned}\frac{dY}{dt} &= \frac{\partial Y}{\partial V}\frac{\partial V}{\partial t} + \frac{\partial Y}{\partial G}\frac{\partial G}{\partial t} + \frac{\partial Y}{\partial K}\frac{\partial K}{\partial t} + \frac{\partial Y}{\partial N}\frac{\partial N}{\partial t} \\ &= \alpha_1\beta_1(e^{a_V})^{-\rho_z}\left(\frac{Y}{Z}\right)^{\rho+1}\left(\frac{Z}{V}\right)^{\rho_z+1}\frac{\partial V}{\partial t} + \alpha_1\beta_2(e^{a_G})^{-\rho_z}\left(\frac{Y}{Z}\right)^{\rho+1}\left(\frac{Z}{G}\right)^{\rho_z+1}\frac{\partial G}{\partial t} \\ &\quad + \alpha_1\beta_3(e^{a_K})^{-\rho_z}\left(\frac{Y}{Z}\right)^{\rho+1}\left(\frac{Z}{K}\right)^{\rho_z+1} + \alpha_2\left(\frac{Y}{N}\right)^{\rho+1}\frac{\partial N}{\partial t}.\end{aligned} \tag{12}$$

Therefore, the real rate of return (marginal productivity) to VOTEC is

$$r_V = \alpha_1 \beta_1 (e^{a_V})^{-\rho_z} \left(\frac{Y}{Z}\right)^{\rho+1} \left(\frac{Z}{V}\right)^{\rho_z+1} , \tag{13}$$

and the rate of return (marginal productivity) to general education is

$$r_G = \alpha_1 \beta_2 (e^{a_G})^{-\rho_z} \left(\frac{Y}{Z}\right)^{\rho+1} \left(\frac{Z}{G}\right)^{\rho_z+1} . \tag{14}$$

Note that the rates of return to each type of education are now determined by the nature of technical progress as well as by the distribution parameters and substitution elasticities. In particular, if VOTEC is technologically progressive, its rate of return will be higher than if it is not. Some VOTEC is not technologically progressive, however. In Indonesia, schools are very severely tracked, and VOTEC often involves learning of simple wood carving, metal working, and weaving skills without any acedemic merits. For these types of VOTEC, the potential gain in the rate of return from technical progress is very low (i.e., $e^{a_V} \approx 0$). Further, vocational skills are usually of the putty-clay type. That is, once the technology in a specific field is embodied, vocational skills are more inflexible and difficult to be adapted to other fields. If VOTEC binds people with illiteracy and innumeracy as is often the case at the junior secondary level, its graduates are quite vulnerable to being technologically displaced. Therefore, if the direction of technical progress is not known clearly, and if general education conveys the capacity to adapt better later (so that $e^{a_G} > e^{a_V}$), than the rate of return will rise over time for general education. This may be one reason why junior secondary vocational schools are being phased out in Indonesia.

IV. EVIDENCE ON RATES OF RETURN

Given the theoretical framework developed in the previous sections, we now turn to some empirical evidence on the rates of return to VOTEC and general education and seek to interpret their meaning in light of this theoretical analysis. Due to the unavailability of suitable data on VOTEC enrollments, we cannot directly estimate the rates of return from the nested CES production function. The time series data for Indonesia has been collected for too short a time span. The 1986 Indonesian data, however, do enable us to calculate the social rates of return by means of the pure internal rate of return. We therefore present social rates of return calculated in this way at the junior and senior secondary school level separately for both VOTEC and general education. As mentioned earlier, we also do this for each region as well as by sex in order to control for geographical aggregation bias and for differences in employment patterns by sex.

In general, the social rates of return to general education are higher than the rates of return to VOTEC at the secondary level. For Indonesia, from the 1982 nation-wide data, the social rate of return to general education was calculated as 23%, which was higher than the rate of return to VOTEC of 19% (McMahon, Millot, and Eng, 1986). For 1986, earnings from the second job were not available, but the nation-wide average rate of return was 19% for senior secondary general and 16% for senior secondary vacational for males (McMahon and Boediono, 1989). For the developing countries as a whole, Psacharopoulos (1985) estimated the social rate of return to general education as 16% and the rate of return to VOTEC as 12%. The relatively low returns to VOTEC is commonly explained by the flatter age-earnings profiles for VOTEC and by higher costs. As shown by the preceding analysis, this difference could also be explained by the lower quality of VOTEC in the sense of less incorporation of technical change than is possible for the general education graduate who receives more flexible and adaptable basic skills.

Table 1 shows a more detailed picture of the rates of return to each type of education. At the junior secondary level, the overall social rates of return are relatively high. For males they are higher for general education than for VOTEC in all of the regions except West Java and Jakarta. This difference does not persist for females at the junior secondary level who usually are trained to do weaving at this level and remain illiterate. It is clear from the table that substantial variations exist with the regions and also by sex.

Table 1 here.

The social rates of return to each type of education at the senior secondary level are given in Table 2. The pattern here is similar to the one that emerges from Table 1. The overall social rates of return are relatively high. Also, for males, VOTEC yields higher returns than general education in only two provinces: West Java and Central Java. In Jakarta, the rate of return is the same 14% for VOTEC and for general education. In the remaining regions, general education yields higher returns than VOTEC. For females, on the other hand, VOTEC yields significantly higher returns only in Sulawesi and the Other Islands, and general education yields higher returns elsewhere.

Table 2 here.

As for the case at the junior secondary level, females mostly receive larger benefits from both types of education at the senior secondary level. The social rate of return to VOTEC is slightly higher for females in all provinces except two, and the rate of return to general education is higher for females in all provinces except one. This difference may again be due to the fact that

foregone earnings are smaller for females than males, but also due to the larger concentration of females in the teacher training and commercial secondary schools.

The results presented here suggest that the educational expansion should occur taking into account the regional differences. The large regional variation in the rate of return to each type of education implies that the relative pay-offs of VOTEC and general education differ substantially, and thus a somewhat different strategy is needed to attain the optimum curriculum mix for each province.

For example, in West Java, the social rate of return to VOTEC exceeds the rate of return to general education at both the junior and senior secondary level for males. It means that benefits of VOTEC and its quality are sufficiently high to cover higher costs of investment compared to general education in that area. Thus, for an efficient growth strategy, VOTEC needs to be expanded at a faster pace than general education for male students in this area. The opposite holds for most of the other regions where the social rate of return to general education exceeds the rate of return to VOTEC.

To sum up, the rates of expansion should not be uniform across the nation. Instead, the optimum VOTEC-general education mix differs in each specific regions, and thus the policy should be based on these regional differences to fit the specific needs of each region.

V. SUMMARY AND CONCLUSIONS

This paper has focused on developing a method to find out more toward the optimum mix of VOTEC and general education in the curriculum. From the standpoint of economic efficiency, the optimum degree of vocationalization of the curriculum is the the one that yields the highest

economic returns later from the educational investments made. The rates of return to VOTEC and general education have therefore been estimated as a way to find this optimum mix.

The second new aspect developed in this paper is the derivation of the rates of return to general and VOTEC education in a nested CES structure, which also takes into account different rates of nonneutral technical progress and their implications for the rates of return.

Finally, we have presented and interpreted updated calculations of the rates of return to VOTEC and general education at the secondary level using the newest 1986 Indonesian data, and broken them down by province. The overall rates of return are relatively high and also slightly higher for general education, especially for males. It implies that both VOTEC and general education are profitable social investments, and both need to be expanded at the senior secondary level but in order to attain a mix that is closer to optimum at somewhat different rates in the different provinces.

NOTES

1. A strong positive correlation of general schooling and the amount of on-the-job training has been demonstrated in Mincer (1989). It has also been observed that graduates of general programs tend to have slightly higher rates of productivity growth from training than vocational program graduates (Bishop, 1989a).

2. The nested CES production function can be specified in alternative ways. For instance, if we include physical capital (K) as another input that has a different substitution relationship with other inputs, the function can then be expressed as

$$Y = [\alpha_1 Z^{-\rho} + \alpha_2 N^{-\rho}]^{-\frac{1}{\rho}}, \alpha_1 + \alpha_2 = 1, \rho \geq -1$$

$$Z = [\beta_1 Q^{-\rho_z} + \beta_2 K^{-\rho_z}]^{-\frac{1}{\rho_z}}, \beta_1 + \beta_2 = 1, \rho_z \geq -1$$

$$Q = [\gamma_1 V^{-\rho_Q} + \gamma_2 G^{-\rho_Q}]^{-\frac{1}{\rho_Q}}, \gamma_1 + \gamma_2 = 1, \rho_Q \geq -1$$

APPENDIX

Computation Methods of Rates of Return

The social rates of return (pure internal rate of return) are calculated for each level and type of education, using the LOTUS program.

The total investment costs of education are composed of foregone earnings and direct costs. Foregone earnings at each education level are estimated from the earnings of school leavers at the next lower level, multiplied by 0.75 (since 3/4 of a year is spent in school), multiplied by the average number of years it takes to complete the education level in question in Indonesia, multiplied by the percent of school leavers at that level that are employed. Foregone earnings are assumed to be zero up through 5th grade. Direct costs are obtained by multiplying the total government expenditure on schools at each level by the number of years it takes to complete each level. The net earnings differential (or returns) is obtained by subtracting the earnings of school leavers at the next lower level from the earnings of those who finished the next higher level.

Then, the LOTUS program solves the non-linear equation to compute the pure internal rate of return using the standard formula. After an initial guess is inserted, the program performs iterations to yield a rate that equates the net present value of the costs to the discounted present value of the stream of returns.

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Table 1. Social rates of return to junior vocational vs. junior general secondary schools, 1986. (Number of cases in parentheses)

	Males		Females	
Province	General	Vocational/ technical	General	Vocational/ technical
Jakarta	5 %	7 %	14 %	14 %
	(303)	(21)	(34)	(3)
West Java	9 %	14 %	12 %	26 %
	(140)	(38)	(39)	(11)
Central Java	11 %	9 %	16 %	15 %
	(170)	(39)	(52)	(5)
Yoguakarta	11 %	NA	25 %	NA
	(44)	(6)	(13)	(0)
East Java	18 %	10 %	16 %	13 %
	(85)	(30)	(31)	(7)
Sumatera	11 %	9 %	14 %	16 %
	(255)	(50)	(59)	(15)
Kalimantan	11 %	8 %	12 %	15 %
	(157)	(22)	(18)	(3)
Sulawesi	15 %	10 %	11 %	24 %
	(132)	(13)	(19)	(2)
Other islands	22 %	13 %	22 %	12 %
	(134)	(33)	(18)	(15)

Note. NA: not available

Table 2. Social rates of return to senior vocational vs. senior general secondary schools, (1986) (Number of cases in parentheses)

	Males		Females	
Province	General	Vocational/ technical	General	Vocational/ technical
Jakarta	14 %	14 %	24 %	25 %
	(412)	(158)	(69)	(62)
West Java	9 %	24 %	17 %	11 %
	(177)	(217)	(71)	(123)
Central Java	12 %	14 %	22 %	18 %
	(199)	(153)	(60)	(94)
Yoguakarta	15 %	NA	NA	10 %
	(58)	(49)	(14)	(25)
East Java	11 %	8 %	15 %	10 %
	(75)	(108)	(23)	(59)
Sumatera	11 %	10 %	17 %	18 %
	(347)	(258)	(82)	(170)
Kalimantan	13 %	11 %	21 %	9 %
	(154)	(132)	(28)	(63)
Sulawesi	14 %	11 %	12 %	19 %
	(210)	(138)	(74)	(97)
Other islands	19 %	8 %	22 %	29 %
	(164)	(253)	(60)	(127)

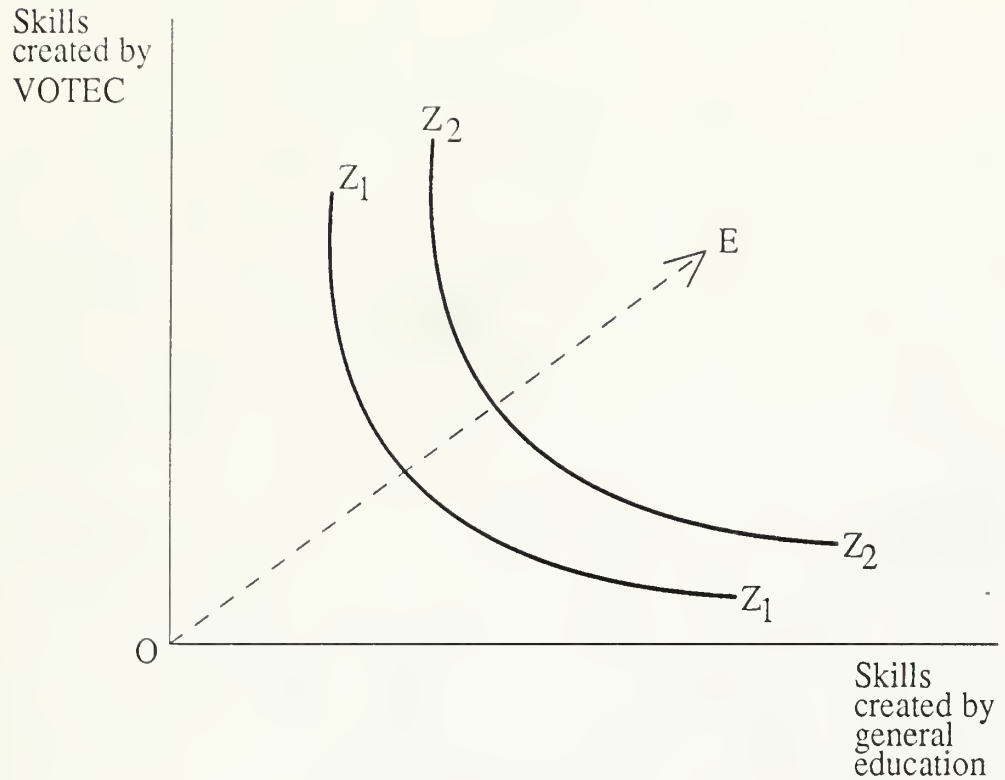
Note. NA: not available

List of Figures

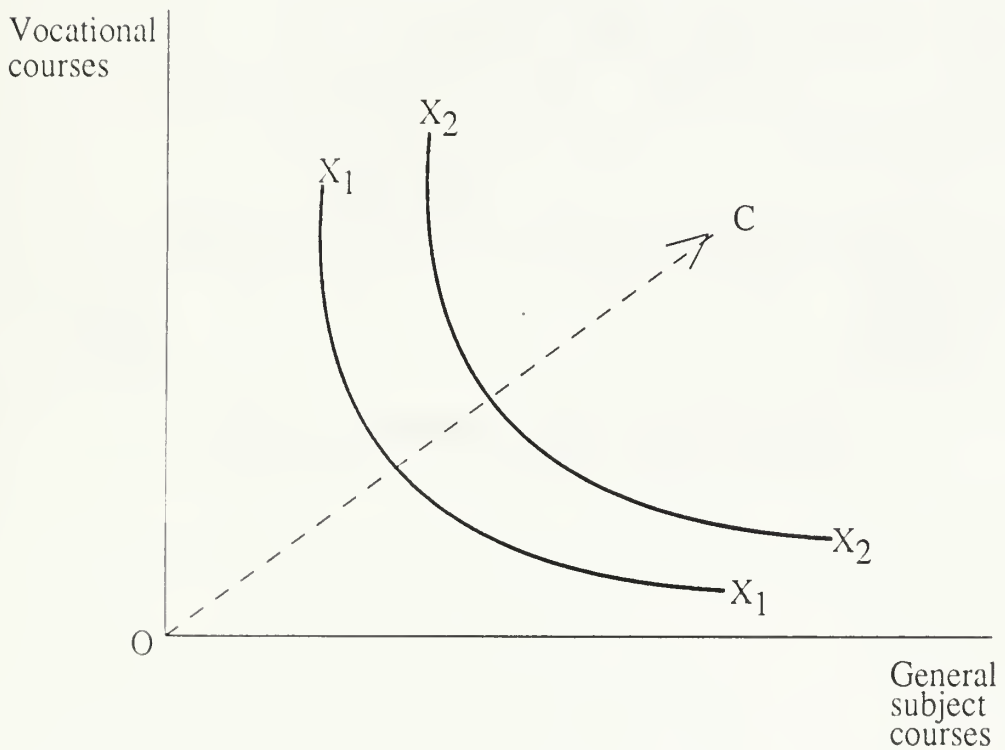
Figure 1. Complementarity in production

Figure 2. The optimum VOTEC-general education mix

Figure 3. Different types of technical progress



1A. Labor inputs with different skills in the economy



1B. Inputs of courses in the curriculum

Figure 1. Complementarity in production

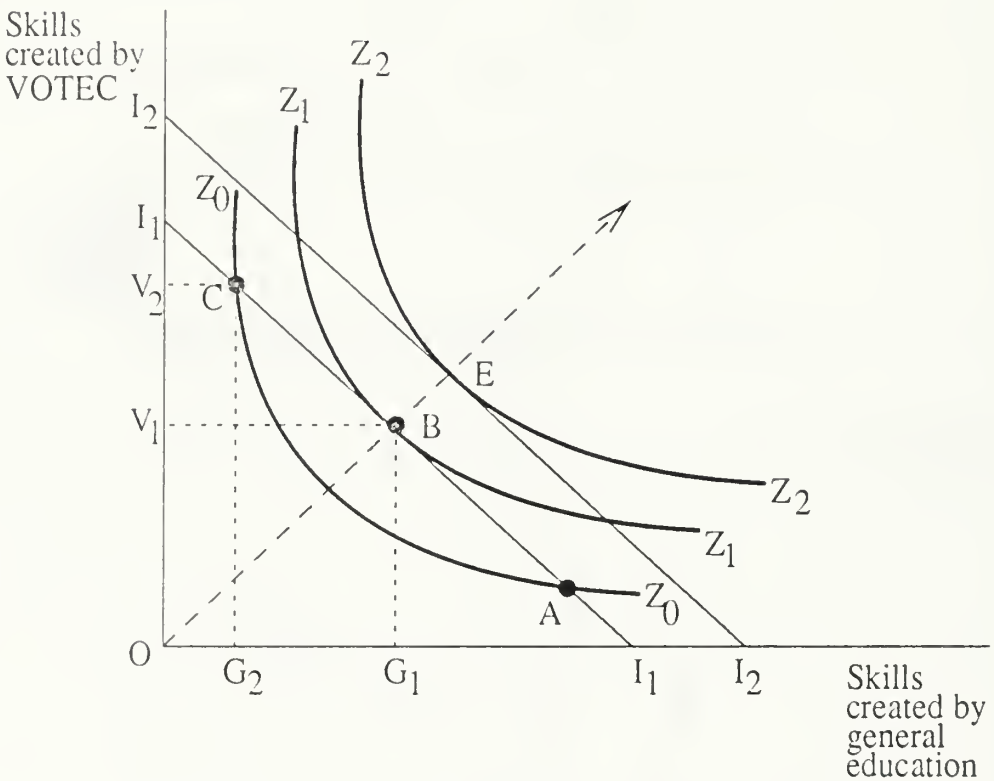


Figure 2. The optimum VOTEC-general education mix

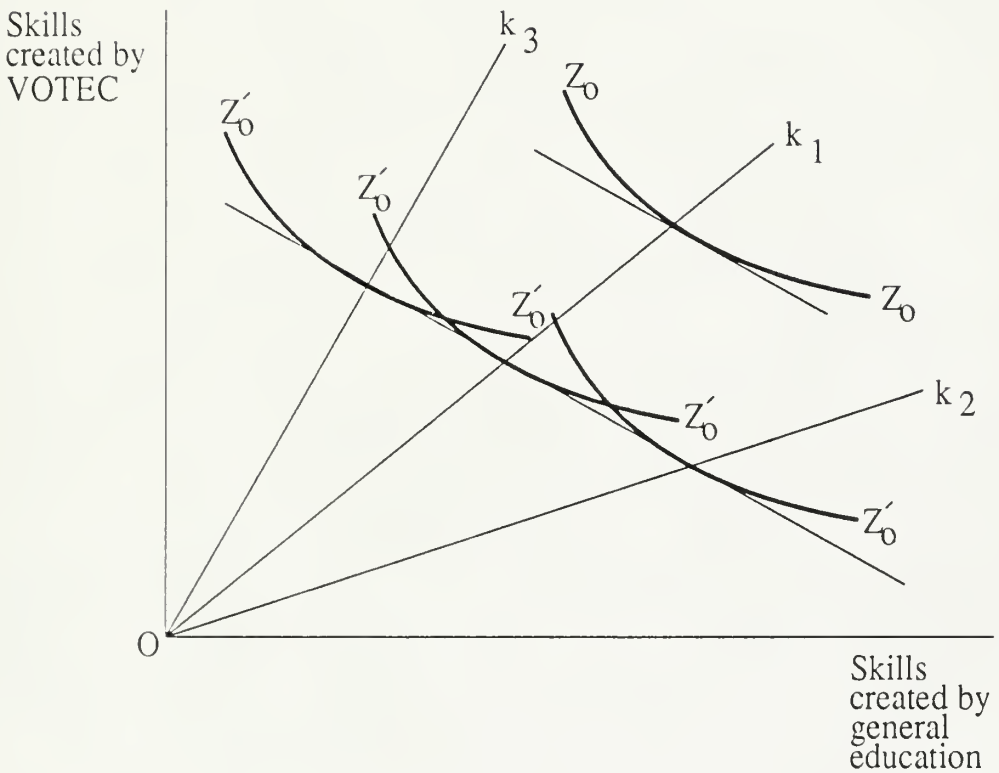


Figure 3. Different types of technical progress

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